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Segmentation of the Indian photovoltaic market☆

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Abstract

This paper provides an analytical framework studying the actors, networks and institutions and examines the evolution of the Indian Solar Photovoltaic (PV) Market. Different market segments, along the lines of demand and supply of PV equipment, i.e. on the basis of geography, end-use application, subsidy policy and other financing mechanisms, are detailed. The objective of this effort is to identify segments that require special attention from policy makers, donors and the Ministry of Non-Conventional Energy Sources. The paper also discusses the evolution of the commercial PV market in certain parts of the country and trends in the maturity of the market.
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1. Introduction

A new technology often requires a period of nurturing and diffusion before it achieves the price/performance ratios that make it attractive to the larger segments of the market. We stand at the cross-roads of time, a defining moment in the evolution of the Indian photovoltaic (PV) industry, a time when it leaves the "Market Transformation" stage and matures to the "commercialization" phase [4]. The Indian PV market has gone through Education, Policy Support, Standards, Demonstration and Industry Involvement stages [11] and is now on the verge of being morphed into a demand-driven market.

2. Background

The carving out of the Ministry of Non-Conventional Energy Sources ('the Ministry' -MNES) in 1992 was intended to provide the Non-conventional Energy Sources (NES) sector with the focus and impetus it required. The first decade since formation has been the hand-holding period, with the Ministry involved in demonstration projects, awareness creation, technology development, and provision of budgetary support to various initiatives. The Ministry functions through various state level 'nodal agencies', which it has helped set-up to implement the given mandate and help disseminate information, technology, finances and know-how. This, combined with the incorporation of The Indian Renewable Energy Development Agency (IREDA) as the world's first financial intermediary solely dedicated to the financing of Renewable Energy (RE) initiatives, was to create the ideal platform for growth of the Indian RE industry.

This paper presents a PV technology specific analytical framework studying the actors, networks and institutions, as suggested by Jacobsson and Johnson [9] and is useful in the enquiry into different ways of supplying energy. This monograph is intended to summarize the evolution of the Indian Solar Photovoltaic (PV) market with emphasis on the segmentation of the PV market from different perspectives. As Blumstein et al. [2] put it, policies rooted in a detailed understanding of the dynamics of real markets are expected to be more effective in the desired transformation. This information would also be valuable to policy makers and help

focus their attention on certain segments that 'lag' behind the others, while, entrepreneurs and financial intermediaries intending to enter the Indian solar PV market would be in a position to select the optimal segment for their entry.

3. Growth of the Indian photovoltaic industry

India today has 9 cell manufacturers, and over 23 module manufacturers [24] with aggregate production capacities of 32 MW of cells and 70 MW of modules and actual production during the year ended March 2003, amounting to 22MW of cells and 23 MW of modules, including 15MW of module exports [17]. According to figures published by the Ministry, module production volumes have been growing at a compounded growth rate of 18.75% per annum for the last six years, while cell production grew at 27.2% p.a. over the same period. In addition, the industry comprises over 60 Balance of System (BoS) manufacturers and system integrators completing the picture. A number of websites related to the Indian PV industry, including the MNES site, host a listing of many of the manufacturers (Fig. 1).

All commercial PV module manufacture in the country is based on crystalline silicon cells while substantial research and development effort continues to go into thin-film (viz., a-Si, CIS, Cd-Te) modules [5,10,19]. It is evident that when produced on commercial scales, thin film solar cells have the potential to drastically reduce prices. Several experts have been of the opinion that thin film solar cells are here to stay [18,25]. The Ministry has supported the set up of an amorphous Silicon (a-Si) thin film solar cell plant in Gurgaon, Haryana, and, the Indian Institute of Sciences, Bangalore, (IISc.) has reported the development of low cost flexible $CuInGaSe_2$ solar cells. (Rediff.com, 2001).

The Indian PV market is expected to remain '*energy-driven*' for the foreseeable future as opposed to the 'environment-driven' Western markets. Over 56.5% of the rural homes, about 77 million in all, spread over 96,000 villages are yet to be electrified [17]. Carlos [3] summarizes that PV technology provides the most cost-effective electrification option in large areas where population is dispersed and electricity demand is low. PV technology, therefore, appears ideally suited to bridge the Indian energy gap, predominantly in the lighting and water pumping segments.

4. Market segments and determinants of demand and supply

4.1. Geographic segmentation

The Indo–US Cooperative Project of 1993 [21] brought in the best in PV technology from the two countries, and built up capacity at India's premier social work organization, the Ramakrishna Mission Ashrama (RKM), in West Bengal. The Sundarban Islands and other remote areas could not be electrified by conventional means and hence the project was a precursor to one of the most intensive deployment of PV technology in the country. Today there are an estimated 30,000 Solar

Home Systems (SHS) and several thousand lanterns deployed in the state of West Bengal, in addition to the large number of PV power plants, and these numbers are rapidly expanding with each passing year. To date, West Bengal represents one of the largest markets for Solar PV systems and power plants in the country and RKM continues to maintain the systems installed under the DoE/NREL initiative as well as those sold subsequently by RKM itself as well as by a few other vendors.

The Ministry's (MNES, 2003) annual targets for the country for March 2003 were 45,000 solar home systems, 1000 AC power packs, 450 kWp aggregate capacity of SPV power plants, street lighting systems, building integrated photovoltaic (BIPV) and other systems and 40,000 lanterns. Cumulatively, 61 MW_p aggregate capacity PV systems and power plants have been deployed for different applications in the country. On aggregate, but with a higher proportion in the states of Uttaranchal, Rajasthan, West Bengal and Kerala, 2800 villages have been electrified through PV in addition to the 520,000 rural households that use stand-alone PV systems for lighting.

The market is generally divided along the lines of state geographies, and the state-level programs are driven by the respective 'nodal agency'. Rajasthan achieved the first position for solar rural electrification in the country for the year ended March 2001, with a deployment of over 8000 systems (Hindu, 2001). Besides numbers of lanterns and street lights (REDA), over 36,000 SHS have been installed in about 1650 villages of Rajasthan, even as the MNES subsidy is progressively reduced to current levels of about 45% of the capital cost.

The nodal agency in Madhya Pradesh (MPUVN) looks at PV more for voltage support at tail ends of the grids with only modest achievements in rural off-grid PV installations. While, in contrast, Kerala (ANERT) has deployed over 1000 kWp of PV, including 19,000 SHS and lanterns in select backward areas, and the Gujarat Energy Development Agency (GEDA) has contributed to the deployment of over 550 kWp of PV in the form of SHS, lanterns, street lights and pumping systems, in the state of Gujarat. Maharashtra (MEDA) has reported a modest number of PV installations, lanterns and SHS sold during the ninth five year plan period (1997–2002) and has set similar targets for the tenth five year plan. In sharp distinction to West Bengal, capital subsidies do not seem to have a significant effect in boosting PV sales in Maharashtra.

As reported by the India Country Gateway, the newly formed state of Chattisgarh plans to electrify 1253 villages including households, police stations and telephone exchanges, in the next two years.

Evidently, the health of the PV market in most states is almost entirely dependent on the direction and emphasis provided by the respective nodal agency. Market development has occurred in the order of priorities set by the nodal agencies through subsidy allocations among other things, and includes at a broad level, the relative importance given to PV over other renewable energy technologies.

Owing to the difficult terrain and remoteness, the markets in the North Eastern (NE) States receive special attention from the Ministry and the industry. The Ministry has targeted the deployment of 5000 SHS and 50 kW_p aggregate capacities of SPV power plants, street lights and other systems in this region for the year ended

March 2003. Cumulatively, the NE region has witnessed the installation of over 3200 street lights, 8600 SHS, and 94 pumping systems, in addition to the deployment of over 38,000 lanterns. Similarly, the entire Ladakh region is considered as 100% electrified. 10,000 solar home lighting systems and 6000 solar lanterns have been installed under the Village Electrification program, which was financed to the extent of 90% by the Central Government.

It is obvious that an optimal mix of geographic conditions helps generate a natural market for PV. Yet, sustainable commercial markets are not created in most of these areas, on account of limited affordability and market distortions caused by capital subsides and annual allocations. The availability and reliability of maintenance and service, appears to contribute positively to the growth of a sustainable market. Clearly, policy instruments have to be tailored to suit local socio-economic conditions in different parts of the country. One needs to evaluate whether the market has matured sufficiently to liberate the Ministry from 'projects' and allow it to focus on 'policy'.

In the South-Western state of Karnataka, the SHS market has grown to almost 40,000 SHS, plus several thousand solar lanterns, sold, installed and serviced by SELCO India, Shell Solar India, Tata BP Solar, and other local and regional vendors, with and without subsidy. The state remains the pre-eminent solar PV market owing to a mix of challenging terrain comprising the Western Ghats, dense forests and settlements remote from the conventional grid and relatively higher levels of rural affordability. The companies are rapidly expanding to include adjoining areas in the neighboring states of Kerala, Tamil Nadu and Andhra Pradesh to form a single South Indian PV market, with sufficient critical mass, offering scale-economies in service provision.

All things considered, one would expect that peninsular India would be the first to transform into a commercial PV market, followed by Central, Western and Northern India. The East/North Eastern Markets would need to evolve substantially to be considered truly commercial.

4.2. Segmentation along financing arrangements

The State, in developing countries such as India, uses subsidy on the price of essential commodities including energy (conventional or otherwise), as an instrument for promoting access to economically disadvantaged individuals or communities. In several countries, such subsidies have succeeded in overcoming the social and economic barriers that restrict the flow of benefits. [15]. The Ministry (Annual Report, 2002–03) has been offering capital subsidies for equipment for the North East (up to 90%) and rest of the country (up to 50%).

The growth in the West Bengal Solar PV market is largely driven by the proactive involvement of the provincial nodal agency (WBREDA[1]), which also administers the subsidy programs announced by the MNES. The market works on the basis of an overall state-subsidy allocation divided among different vendors to sup-

[1] West Bengal Renewable Energy Development Agency.

ply SHS of pre-specified technical specifications and pre-determined prices and levels of capital subsidy. The Agency is credited with the creation of the high level of awareness in the rural areas about the technology and the subsidy schemes. Vendors, however, have been unable to break out of the subsidy mindset and market growth has been constrained by the availability of capital subsidies.

In general, subsidies reach those who can mobilize the net-of-subsidy cost of the system. Further, as Okese and Mapako [14] point out, the subsidies that cannot be sustained beyond the life of the project are worthless. Moreover, the product has to be maintained for the entire duration of its useful life, failing which, the subsidy is rendered useless. An analysis of the effectiveness of the consumer subsidy would necessitate a comparison of prices and volumes with those that would hypothetically be realized in the absence of the "price distortions". The difficulty with this approach is the estimation of appropriate elasticities [20]. In rural areas, for instance, customers could potentially end up borrowing the net-of-subsidy amounts from the informal credit market at usurious rates. Thus, creation of viable sources of commercial consumer finance is vital for the sustainability of projects [6].

The Indian Renewable Energy Development Agency (IREDA) was founded in 1987 to do just that—to provide small loans and business development skills to Indian entrepreneurs, and specifically for the creation of appropriate marketing and financing mechanisms ideally suited to the unique requirements of renewable energy technologies. IREDA was meant to bear a greater degree of risk than commercial institutions. In practice [7], as it turned out, IREDA sought a rather unreasonable 100% guarantee on its debt, and combined with the reputation of being excessively "bureaucratic", effectively dissuaded project developers from seeking assistance. IREDA was a government organization, and therefore had to conform to Government of India operational procedures; was further subjected to the World Bank procurement norms as it was managing the World Bank Line of Credit, while simultaneously, it was expected to be flexible and responsive to serve the private sector—three positions that could not be reconciled easily. In addition, Financial Intermediaries often exploited the interest arbitrage by resorting to financial engineering to create a single up-front lease payment for PV systems, and not providing longer term low-cost credit to the end customers. The intermediaries thus chose to give up long-term sustainable business opportunities in favor of short-term gains, defeating the very purpose of the seed capital/concessional funding.

The Northern, Central and Western Indian markets of Uttar Pradesh, Uttaranchal, Chattisgarh, Madhya Pradesh, and Rajasthan, continue to evolve largely on the back of the subsidy programs announced by the Central Ministry as well as the provincial governments, wherever applicable. They are yet to witness large scale commercial PV sales and service operations outside of the realm of the subsidy program.

In contrast, the market in Karnataka and neighboring states has evolved and matured through the participation of the commercial banking sector. Nationalized banks viz. Canara Bank and Syndicate Bank, through their Regional Rural Bank subsidiaries and cooperative banks, have contributed substantially to the growth of the market and the visibility to the technology. The United Nations Environment

Program (UNEP, 2003) has announced a back-ended interest subsidy program to 'buy down' the interest cost for SHS customers through the two banks and hopes to reach 18,000 customers. Micro-finance institutions operating in these areas are increasingly involved in PV-lending as well, either in partnership with certain vendors or for PV systems in general.

Capital subsidy has the effect of creating awareness but stunts innovation and is limited in replicability and sustainability of the effort, in the absence of subsequent budgetary allocation. The good thing, however, about the subsidy situation in India is the nature of evolution—the progress of the market is reviewed periodically and the subsidy policy is regularly updated. For instance, the subsidy on the solar lantern has been phased out while larger SHS (viz. 74 Wp) and AC power packs (e.g. for internet kiosks) are brought within the ambit of the subsidy schemes.

4.3. Segmentation along end-use applications

The focus of the Ministry is simultaneously evolving as the demand patterns in the PV market emerge. It has recently moved away from a technology-wise departmentalization and has migrated to an organization structure comprising 'Minimum Rural Energy Needs', 'Decentralized Energy Supply', 'Grid-connected Power Supply' and 'Exports' [24]. Solar PV products and systems such as lanterns, SHS, power packs and power plants and modules are covered in the entire range of the spectrum.

Estimates indicate that about 385,000 lanterns have been deployed, representing about 25% of all solar modules used for rural electrification in the country. Considering that adequate experience has been gained with manufacturing, marketing and service in this segment, the MNES capital subsidy on solar lanterns has been phased out in the financial year commencing April 2002. This has enabled entrepreneurs to innovate with technical specifications and aesthetic designs, not conforming to those laid down and rigorously enforced by the MNES subsidy programs. Consequently, solar lanterns with a range of specifications and models are sold as consumer durables and as back-up lighting during brown outs, at different price points in rural as well as urban areas.

Right from the days of the DoE/NREL program cited above, SHS have been the most visible and reported product segment being the focus of subsidy programs, electrification schemes as well as most commercial energy service providers. By March 2004, we expect to see over 600,000 SHS deployed in the Indian market. The increasing availability of finance for SHS from mainstream commercial sources is expected to grow the market exponentially in the ensuing period of time, simultaneously increasing installation-density. Low customer density in a given service territory makes sales, installation, service and payment collection expensive and difficult, giving rise to transaction costs which are in the order of 30% of the total system costs [26]. This reduces affordability, undermines sustainability of systems and diminishes the effect of reduction in PV module prices.

Solar power plants and the associated mini-girds are presently run as independent rural utilities by the local governments, largely funded by central and state government capital subsidies, with monthly revenues intended to cover operational costs and repayment of the debt (capital cost net of all subsidy). However, it is not clear whether the power plants have been commercially viable, i.e. whether they generate revenues sufficient to cover maintenance and operation costs and for the debt servicing. Martinot et al. [12] conclude that to ensure sustained service provision, it is essential to budget for items such as battery replacement, either from profits or from subsidies. A number of such plants are being constructed on islands, and in the North and East of India to provide power supply to hospitals and other institutions as well as for isolated clusters. The installation and service costs of these plants are borne by the governments.

Grid-connected power plants have been installed mainly for voltage support systems at rural grid tail ends and for demonstration of peak load shaving in urban centers. Street lighting systems, similarly, have been supplied in large numbers under the subsidy programs but evidently, the commercial PV street light market is a few years ahead of us.

Some of the provincial governments, with MNES support, choose to limit the liability arising out of the loss making power-supply arrangements to agriculturists and far flung areas and supply subsidized PV pumping systems instead. This is in addition to the ongoing MNES programs for promoting Solar PV pumping systems. For the moment, the segment remains limited to the subsidy programs as the un-subsidized product would not be in a position to compete against the Rs.110/Wp subsidy on the system (perspective: module prices ranging Rs.150 and approximately 1US$ = INR 45). In all, the subsidy and the low-cost debt have resulted in the installation of over 5600 pumps, country-wide [17].

The PV-for-telecom market has shown signs of revival with licenses being awarded for private sector participation in telecom installation and service provision. Modules employed at the consumer end of the service chain are smaller—in the range of 12 Wp rating—while those at the base stations and other nodes would be much larger. PV is increasingly being employed in security and fencing applications for agricultural lands as well as properties perceived to be under threat.

PV torch lights and small gadgets have been in the market for a while but have not been marketed aggressively. One of the PV vendors is setting up a nation-wide supply chain for showcasing and selling environment-friendly and energy-efficient equipment. The company has successfully commenced retailing imported and indigenously built Solar PV consumer gadgets in urban and semi-urban markets. These gadgets are positioned as life-style products and include flash lights, radios, toys etc., which contribute greatly to demystifying the technology and bringing it closer to people. As Yang et al. [26] analyze, (PV powered) consumer products are market-led in a purely commercial environment, the growth of the market is influenced by general economic factors.

The Ministry has rolled out a network of about 35 retail outlets, branded as the "Aditya" (literally, the "Sun") Solar Shops, with ten more in different stages of construction (MNES, 2003). These outlets serve as demonstration and sales outlets

for solar thermal and PV equipment and other energy-efficient products. Outlets which are supported by an active field sales and service team tend to be commercially more successful indicating that we have, perhaps, not reached a stage where PV technology sells off-the-shelf.

4.4. Segmentation by module markets

The Indian PV module manufacturing industry comprises cell and module manufacturers who import silicon wafers and process them into cells and modules. The industry is divided into government corporations such as Central Electronics Limited (CEL), Bharat Heavy Electricals Limited (BHEL) and Bharat Electronics Limited (BEL) and private or joint sector manufacturers such as Tata- BP, Webel-SL, USL Photovoltaics, Microsol Power, Maharishi Solar etc. After the February 2003 inauguration of the 38 MW facility, manufacturing capacity is skewed with one company, the joint venture between BP and the Tata Group, owning about 50% of the country's installed capacity. The rest of the industry is, in general, fragmented though intra-industry trade in cells and modules is evident.

The erstwhile Department of Telecom (DoT) absorbed much of the industry's output of Solar PV modules in the country [24] along with the Indian Railways and other large/government owned Corporations. However, by the mid-nineties, the orders from these segments tapered and most manufacturers were left with unutilized capacity and accumulated inventories. This motivated the manufacturers to look towards export markets, to support their survival, which coincided with the boom in uptake from the European roof top market.

The other category of export is the module production, which is outsourced to India by manufacturers for re-export to Europe, Africa, China and other markets. Since most Indian module manufacturing operations are labor-intensive, they tend to be very flexible and operate at competitive costs of production when compared to the more automated plants in the West. Many of the Indian module makers have obtained international certification for their operations and their product to enhance their image in the highly competitive markets abroad. In fact, certification from either a European or an American agency is more than a selling proposition, and has become a precondition for PV module sales in most export markets. Progressively, India is seen as a high-quality, low cost manufacturing base for small modules (viz. upto 70 Wp rating), made from imported wafer or from imported cells. Looking beyond the USA, Germany and Europe, and to diversify and grow, the module industry has turned its attention to Africa—a potentially large market and has entered into different supply arrangements.

Module manufacturers have, thus, divided their attention between the export and the domestic markets. Even while the export market is crowded, the industry has been successful in selling about 70% of its total production abroad, proving international competitiveness. The ongoing fiscal and financial incentives, duty concessions, and lower cost of capital and the availability of, reliable indigenous equipment for module manufacturing in India, have also contributed to the recovery of the sector. It remains to be seen how the industry responds and performs

when tariffs on the import of solar modules are reduced and international brands enter the Indian market.

4.5. Segmentation by function

The most significant development for the Solar PV industry in the country is the formal delineation of roles of the different players in the sales and service delivery chain, originating in the core competence of each participant. The manufacturers preoccupied with the export market, for instance, prefer to leave the power plant installation and the marketing and sales of SHS and lanterns to system integrators. Restricting themselves to module supply, frees up valuable working capital, in a sector which appears to suffer from chronic illiquidity. The integrators focus on marketing and sales either through their own network or through commission sales agents. In highly evolved markets, service is outsourced to franchisee technicians, generally running independent businesses viz. radio and television service. While this is a part of the natural evolution of the market, it has been accelerated, and in-turn supported, by specific initiatives such as the US$ 30 m IFC/GEF Photovoltaic Market Transformation Initiative (PVMTI[2]) (Fig. 1).

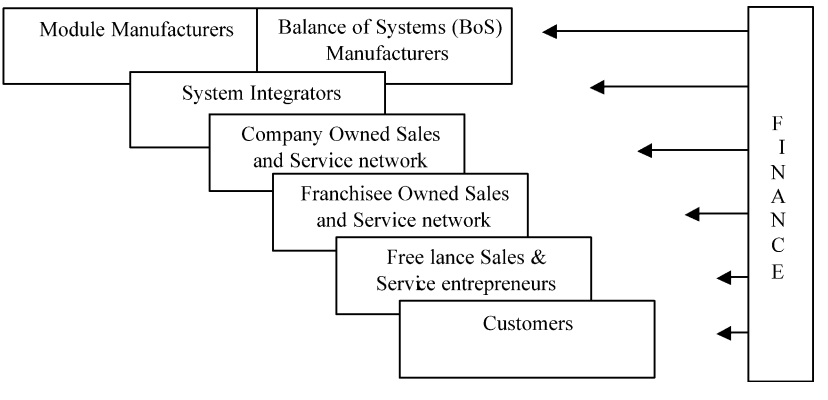


Fig. 1. Segmentation of the Indian PV market by function of constituents.

Further, this break-up of the processes has enabled mainstream financial intermediaries and commercial banks to step in at different levels of the value chain to fulfill the financing requirements—capital equipment for the manufacturers, working capital for the integrators and franchisees and consumer finance for the end users. This has obviously changed since the mid nineties when banks viewed renewable energy projects as development oriented [13] and were not convinced of the commercial potential even as project developers grappled with financial constraints. To achieve 10% of additional power generation capacity by 2012 from

[2] www.pvmti.com

renewable sources, additional investments to the tune of US$12b [16] would be required and about 90% of this is expected to be brought in by the private/mainstream financial sector.

In addition the Ramakrishna Mission, Jadavpur University training programs in West Bengal and the Tata BP, SELCO, Shell Solar and similar initiatives in Karnataka have created a large pool of trained technicians to help install and service the PV systems.

4.6. The future of the Indian PV market

We find ourselves in an exciting stage of the evolution of the Indian Photovoltaic Market. The tenth five year plan (2002–2007) outlines deployment of 200 MW of PV systems with 60 MW of those under the Ministry's subsidy programs [17,23]. In the medium term, the country's eleventh five year plan ending 2012, expects to witness the cumulative deployment of 5 million solar lanterns and 2 million SHS [24]. Suganthi and Williams [22] have modeled the energy scenario in India in 2020 and 2021 and have found that Solar PV could contribute in the region of around 7.3% of the total energy requirement, predominantly for lighting and pumping applications. It is thus possible to visualize a virtuous cycle of market growth, expanded production and further economies of scale, according to Jackson and Oliver [8] that would 'shortly' enable PV technology to compete for an increased presence in the energy mix. The wide-spread availability of skilled resources further accelerates this market growth which reciprocally contributes to the growth of the resource base.

The decline in international module prices is fuelled by technological improvements and innovation, the slow down in demand from the European rooftop market and the coming on stream of large capacity plants overseas. With the concomitant increase in Indian production capacities most Indian manufacturers seek to increases their domestic presence. The most exciting phase would commence when the declining prices of PV technology converge with increasing and subsidy-free diesel and kerosene prices where the urban grid-connected market would be opened to PV. The costs of providing services to the urban sector and of collecting payments would be a fraction of that for the rural areas and when combined with adequate installation density, could give birth to the fee-for-service market in India. This segment would receive a huge boost consequent to the restructuring of the state electricity boards and the introduction of 'net-metering' and other relevant policies recommended by the State Electricity Regulatory Commissions. The long-term economics of this segment would also be influenced by the trading of ecological benefits which depend on the CO_2 emissions from the PV production and end-of-life recycling processes [1].

The response of the Indian PV module manufacturing sector would be based on relevant developments, including the evolution of the exchange rates of the Indian Rupee against the US Dollar and the Euro, the movement in diesel and kerosene prices and the trends in international module prices as well. By the end of the tenth five year plan (2007), the demand and supply dynamics of the three solar PV

market segments, namely the government, commercial and consumer would go through an overhaul—we could expect a redefinition of the commercial segment and a dramatic growth in the consumer segment, in both rural as well as urban areas.

Website references

ANERT, Kerala, www.kerala.gov.in/dept_power/anrt_progrms.htm
GEDA, Gujarat, http://www.geda.org.in/installation.htm
Hindu, The www.hinduonnet.com/thehindu/2001/03/04/stories/1404221e.htm
India Country Gateway “Solar Energy Project”, The Hindu 4 Aug 2002.www.incg.org.in/CountryGateway/RuralEnergy/News/solarenergy.htm
MEDA, www.mahaurja.com/html/main_solar.htm
MNES, www.mnes.nic.in
MPUVN, Madhya Pradesh, www.mprenewable.org/solar/solar.htm
REDA, Rajasthan, www.rajenergy.com/reda.htm
REDIFF.COM: “Indian Scientists Develop New Solar Cell”, (Jan 05, 2001). http://www.rediff.com/news/2001/jan/05solar.htm
UNEP, “Energy Finance: Program Overview” www.uneptie.org/energy/act/fin/india/overview.htm

References

[1] Alsema EA, Nieuwlaar A. Energy viability of photovoltaic systems. Energy Policy 2000;28: 999–1010.
[2] Blumstein C, Goldstone S, Lutzenhiser L. From technology transfer to market transformation. June 2001. http://www.ucei.berkeley.edu/Recent_Presentations/From_Tech_Transfer_to_MT.pdf
[3] Carlos JC. Photovoltaic technology and rural electrification in developing countries: the socio-economic dimension, IPTS Report No. 19. www.jrc.es/iptsreport/vol19/english/ENE1E196.htm
[4] Chaurey A, Rao NYD. A review of renewable energy policy and financing in India. New Delhi, India: Tata Energy Research Institute; 2003.
[5] Dasgupta A, Lambertz A, Vetterl O, Finger F, Carius R, Zastrow U, Wagner H. P-layers of microcrystalline silicon thin film solar cells. 16th European Photovoltaic Solar Energy Conference and Exhibition 2000, paper no. [447] VB1/38.
[6] GEF. Results from the GEF Climate Change Program—Evaluation Report # 1-02. Monitoring and Evaluation Unit, Global Environment Facility, 2001.
[7] Hodes SG. Sustainable finance for sustainable energy: the role of financial intermediaries. Sheffield, UK: Greenleaf Publishing Limited; 2001, p. 412–430.
[8] Jackson T, Oliver M. The viability of solar photovoltaics. Energy Policy 2000;28:983–8.
[9] Jacobsson S, Johnson A. The diffusion of renewable energy technology: an analytical framework and key issues for research. Energy Policy 2000;28:625–40.
[10] Jain K, Sharma RK, Kohli S, Sood KN, Rastogi AC. Electrochemical deposition and characterization of cadmium indium telluride thin films for photovoltaic applications. Current Applied Physics 2003;3:251–6.
[11] Kumar A, Jain SK, Bansal NK. Disseminating energy-efficient technologies: a case study of compact fluorescent lamps (CFLs) in India. Energy Policy 2003;31:259–72.
[12] Martinot E, Cabraal A, Mathur S. World Bank/GEF solar home systems projects: experiences and lessons learned 1993–20000. Renewable & Sustainable Energy Reviews 1993;5:39–57.

[13] Naidu BSK. Indian scenario of renewable energy for sustainable development. Energy Policy 1996;24:575–81.
[14] Okese YA, Mapako M. Solar PV rural electrification lessons from South Africa and Zimbabwe. Riso International Energy Conference, Riso National Laboratory, Denmark, May 2003.
[15] Pandey R. Energy policy modeling: agenda for developing countries. Energy Policy 2002;30:97–106.
[16] Puri S. RE policy in India: the need for local sensitivity. REFocus, November–December 2003
[17] Sastry EVR. The photovoltaic market in India. IEA–PVPS Conference, Osaka, Japan, May 2003.
[18] Shah A, Torres P, Tscharner R, Wyrsch N, Keppner H. Photovoltaic technology: the case for thin film solar cells. Science 1992;258:692–98.
[19] Sharma S, Kohli S, Rastogi AC. Role of cadmium-related defects on the structural and electrical properties of nanocrystalline CdTe:TiO_2 sputtered films. Current Applied Physics 2003;3:263–7.
[20] Steenblik RP. A Note on the Concept of 'Subsidy'. Energy Policy 1995;23:483–4.
[21] Stone JL, Ullal HS, Sastry EVR. The Indo-U.S. cooperative photovoltaic project. 26th IEEE Photovoltaic Specialists Conference, California 1997.
[22] Suganthi L, Williams A. Renewable energy in India—a modeling study for 2020–2021. Energy Policy 2000;28:1095–109.
[23] Tenth Five Year Plan (2002–2007) the Planning Commission, Government of India http://planningcommission.nic.in/plans/planrel/fiveyr/welcome.html
[24] TERI. Survey of renewable energy in India. New Delhi, India: Tata Energy Research Institute; 2001.
[25] Ullal HS, Zweibel K, von Roerdern BG. Current status of polycrystalline thin film photovoltaic technologies. 26th IEEE Photovoltaic Specialists Conference, 1997, Anaheim, California (NREL/CP-520-22922 • UC Category: 1250)
[26] Yang H, Wang H, Yu H, Xi J, Cui R, Chen G. Status of photovoltaic industry in China. Energy Policy 2003;31:703–7.